AD-A278 190

REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	May 1991	Technical April 91 - May 91

4. TITLE AND SUBTITLE
Analytical Assessment of the Suitability of a Liquid Explosive Substitute for Shaped Charge Testing

5. FUNDING NUMBERS
C

(2)

6. AUTHOR(S)
Steven M. Buc

DTIC ELECTE APR 18 1994 S F D

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
System Planning Corporation
1500 Wilson Blvd
Arlington, Virginia 22209

8. PERFORMING ORGANIZATION REPORT NUMBER
SPC 91-282-5

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Advanced Research Projects Agency (ARPA)
3701 North Fairfax Drive
Arlington, Virginia 22203-1714

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

94-11489

11. SUPPLEMENTARY NOTES
Contract No. MDA972-90-C-0044

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

In this analysis, a 95% nitromethane (NMe) and 5% diethylamine (DEA) liquid explosive is substituted into a BRL 3.3 inch 42 degree conical copper lined charge. The original charge is Octol loaded. Since NMe is less energetic, it is expected to give a reduced jet tip velocity, less jet mass, and lower overall jet kinetic energy. This would naturally follow from the use of a lower energy density explosive. The liquid explosive load will then be modified by a combination of liner subcalibering and detonation front wave shaping to investigate how the original jet characteristics may be recovered.

94 4 15 046 DTIC QUALITY INSPECTED 3

14. SUBJECT TERMS
shaped charge jetting model, liquid explosive, Gurney energy, Octol, nitromethane, wave shaping, finite difference methods

15. NUMBER OF PAGES 27

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

SPC 91-282-5

ANALYTICAL ASSESSMENT OF THE SUITABILITY OF A LIQUID EXPLOSIVE SUBSTITUTE FOR SHAPED CHARGE TESTING

MAY 1991

Prepared for

Dr. Terry Phillips
Program Manager
Advanced Chemical Energy Warhead Program
Tactical Technology Office
Defense Advanced Research Projects Agency
1400 Wilson Blvd
Arlington, Virginia 22209

By

Steven M. Buc

Introduction

The question was raised as to the suitability of using a 95% nitromethane (NMe) and 5% diethylamine (DEA) liquid explosive, currently in use by the Royal Armament Research And Development Establishment (RARDE), as a quick turn-around, easy-to-load, and uniform explosive loading for developmental liners under the Advanced Chemical Energy Warhead Program. There is precedent for using substitute explosives during liner materials investigations and liner design development, primarily to ensure consistent, precise loading quality and as well as for convenience and lower cost. The use of alternate explosives, however, is only suitable to the point that the substitute explosive does not significantly alter the conditions under which the intended liner is to be employed, or adversely affect those material and liner parameters under investigation.

In this analysis, the NMe liquid explosive will be substituted into a BRL 3.3 inch 42 degree conical copper lined charge. The original charge is Octol loaded. Since the NMe is less energetic, it is expected to give a reduced jet tip velocity, less jet mass, and lower overall jet kinetic energy. This would naturally follow from the use of a lower energy density explosive. The liquid explosive load will then be modified by a combination of liner subcalibering and detonation front wave shaping to investigate how the original jet characteristics may be recovered.

Approach

The most precise approach to analyzing the performance tradeoffs between the two explosive loads is to use a hydrocode simulation. The hydrocode allows accurate modeling of the detonation and gas pressures behind the liner over the entire collapse duration. The effects of charge confinement and rarefaction shock waves on the collapse velocity are also readily apparent in the simulation. Placing tracer elements along the liner contour allows the collapse velocity to be monitored and the collapse angle to be calculated. Once the elements reach the axis, application of the hydrodynamic equations for jet formation readily follows.

Without the use of a hydrocode to determine the liner collapse velocity, as in this analysis, an approximation is required. Two possible formulations present themselves. The first is to assume a pressure history behind the liner, beginning with a peak at the detonation pressure, and then diminishing linearly or quadratically to some final value, based on the charge confinement. Not knowing with confidence how confinement and rarefaction waves affect the pressure history, a second approach was formulated based on the Gurney equations. The Gurney equations provide a final plate velocity which accounts for both charge height and charge confinement. The first problem with this approach, however, is that Gurney velocities are based on experiments with parallel plates and only provide final velocities for the entire plate, not discrete sections. Application of this to axi-symmetric conical shaped charge liners clearly violates this condition. This approach also does not provide an acceleration history of the liner element, and it is well known that the apex of the liner generally reaches the axis prior to realizing its full velocity potential. In addition, the angle of incidence of the explosive detonation front affects the acceleration time, although it generally does not affect the final velocity of the plates.

It is true that the Gurney velocities are experimentally determined on a geometry radically different from a shaped charge. However, intuitively, the shaped charge application of the Gurney equations must be a more general case of the actual experiments. In other words, they are related.

The Model

The acceleration of the liner elements is based on the Gurney equations for an asymmetric explosive sandwich. The liner, explosive charge, and confinement are divided into 100 discrete segments, which facilitates the calculation of charge to mass and charge to confinement ratios. Working in terms of charge, liner, and confinement masses neglects any effects of the cylindrical geometry in the shaped charge. Figure 1 presents the applicable equations as taken from Reference 1.

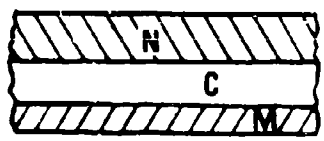
ASYMMETRIC CONFIGURATIONS

Open-faced Sandwich:

$$\frac{v}{\sqrt{2E}} = \left[\frac{\left(1 + 2\frac{M}{C}\right)^3 + 1}{6\left(1 + \frac{M}{C}\right)} + \frac{M}{C}\right]^{-1/2} \qquad (4)$$

Asymmetric Sandwich:

(tamper)



$$\text{Define } A = \frac{1 + 2\frac{M}{C}}{1 + 2\frac{N}{C}} \; ;$$

$$\frac{v_M}{\sqrt{2E}} = \left[\frac{1 + A^3}{3(1 + A)} + \frac{N}{C}A^2 + \frac{M}{C}\right]^{-1/2} \qquad (9)$$

Symbols: $\frac{M}{C} = \frac{\text{total metal mass}}{\text{total explosive mass}}$; $\frac{N}{C} = \frac{\text{total tamper mass}}{\text{total explosive mass}}$

v = metal velocity

Gurney energy, E = kinetic energy/unit explosive mass

Figure 1 Gurney Equations

Each liner element is assumed to achieve 85-90 % of its full Gurney velocity within the time it takes the release wave to arrive radially from the charge confinement. The release wave speed is assumed to be the explosive detonation speed. This formulation allows for the condition where liner elements reach the axis prior to full acceleration. The acceleration history is assumed to be exponential, beginning with zero velocity when the shock front arrives at the element, rising to 85-90% of maximum velocity by the time the release wave reaches that element from the charge perimeter, and then 100% Gurney velocity is realized at an effectively infinite time. The 85-90 % Gurney velocity term in the formulation was chosen because it fit jet tip velocity data for known shaped charges. For the octol loaded 3.3 inch charge in this analysis, using 90% gives the best results.

The model also incorporates plane wave detonation fronts, as well as point and ring initiation at a defined charge head height behind the apex of the liner. When a liner is modeled using a rounded apex, it is best to cut the apex off and ignore it. In this region the accuracy of charge to mass ratio calculations are questionable, the liner material has very little run distance to the axis so it usually has a strong reverse gradient, resulting only in a massive jet tip. This model will not accurately handle these rounded apexes, which behave more truly like hemispherical liners.

Results

Figure 2 presents the 3.3 inch BRL standard shaped charge as taken from reference 2, which was the baseline charge for this analysis. Figure 3 shows the computer mesh with 100 liner, explosive, and confinement elements. The charge is Octol loaded, which has a Gurney velocity of 2.83 mm/usec, detonation velocity of 8.5 mm/usec, and a density of 1.82 g/cc. Point initiating this charge at a head height of 67.6 mm gives the following jet parameters according to the model:

Baseline Octol Charge (BOC)

Vtip (element 13); mass	8.31 mm/usec ; .177 gr
V (element 100); mass	0.33 ; 2.77
Jet mass	71.6 g
Jet energy	.543 megajoules

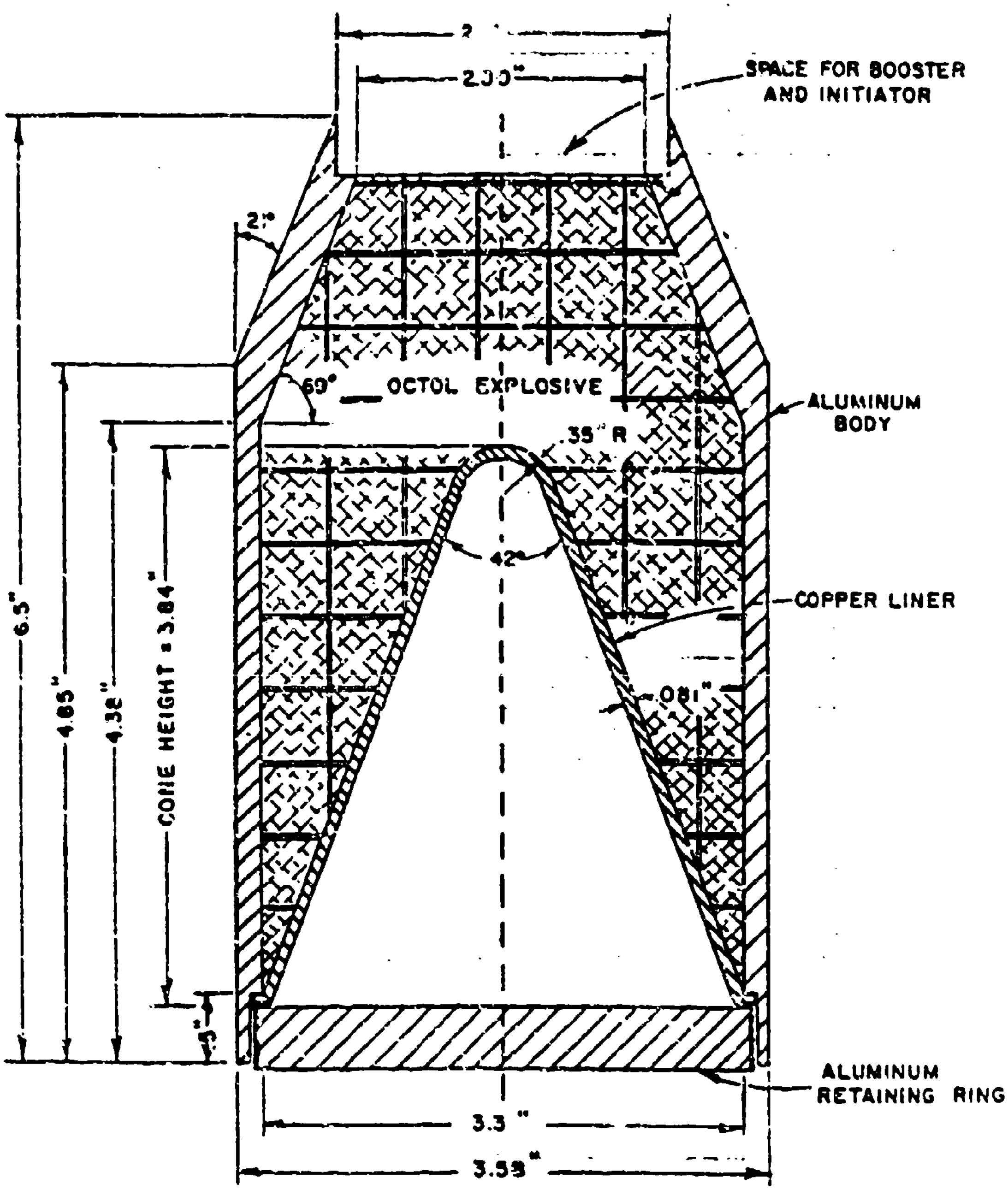


Figure 2. Baseline Octol Charge

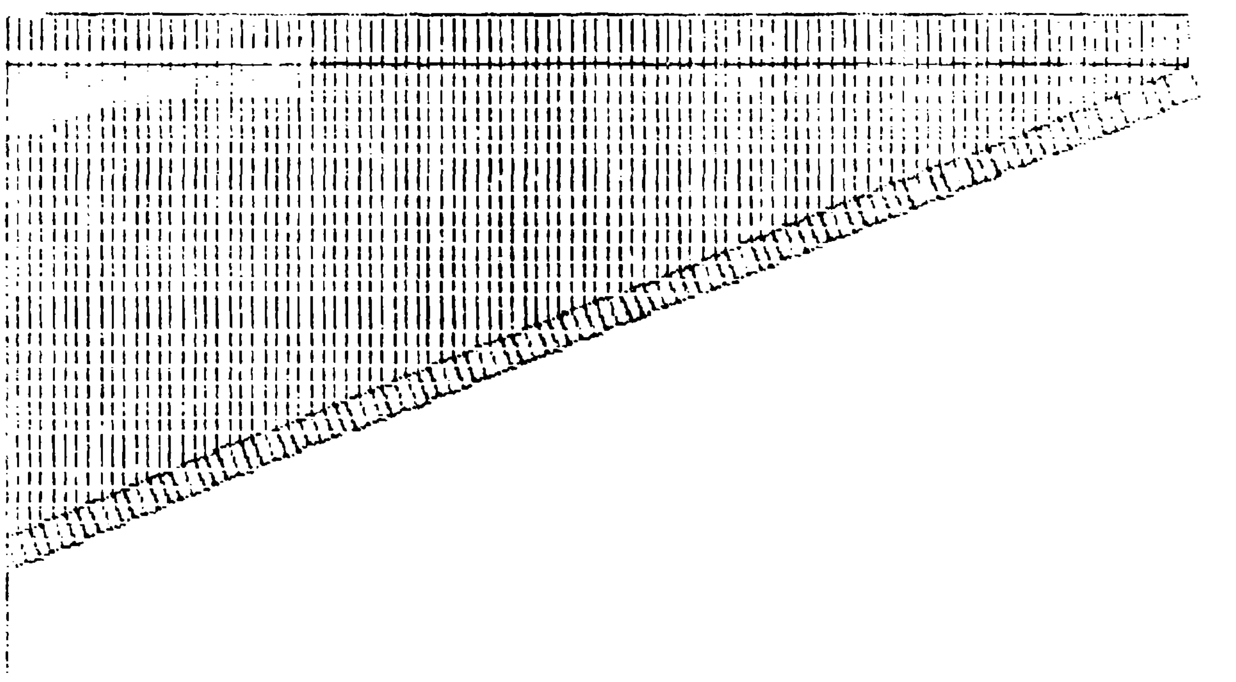


Figure 3. Computer Mesh of Baseline Octol Charge
(Only one half of axi-symmetric shape shown)

The jet tip has a slight reverse gradient from element 1 back to element 13, where the momentum averages out. Actual test data for this charge gives a tip velocity of 8.30 mm/usec.

The NMe liquid explosive has a detonation velocity of 6.3 mm/usec, and density of 1.1 g/cc. The Gurney velocity for this explosive is unknown to us, so it was estimated based on a linear extrapolation from Octol through TNT, which is closer in properties to the NMe than Octol is. The Gurney velocity is assumed to be a function of the pressures behind the liner as it accelerates. These pressures should be a function of the explosive density times the detonation velocity squared. Knowing these parameters for Octol and TNT (V det 6.95, density 1.65, V Gurney 2.37) yields an estimate of 2.04 for the Gurney velocity for the NMe. Running the same charge with NMe yields the following results:

Baseline Liquid Charge (BLC)

Vtip (element 5); mass	5.67 mm/usec ; .128 g
V (element 100); mass	0.19 ; 2.76
Jet mass	69.3 g
Jet energy	.206 megajoules

There has been a significant drop in jet tip velocity and jet energy. About 10% of jet mass is lost in the forward portion of the jet, but recovers somewhat in the rear portion. The overall jet mass is nearly the same. However, useful jet mass (above 2 km/sec) reduces from element 84 in the baseline charge to element 72 in this charge.

Since the jet tip velocity dropped so dramatically, no run was made using a plane wave detonation front to simulate more explosive head height. Something more drastic was needed to bring jet tip velocity up. Going to ring initiation allows the detonation front to sweep by the liner faster, artificially increasing the detonation velocity, resulting in a lower collapse angle. This should increase tip speed. However, it will be at a cost of lower jet tip mass.

Initiating the liquid charge at a head height of 20 mm and 40 mm off axis, or ring initiation at the charge perimeter, gives the following results:

Ring Initiated Liquid Charge (RILC)

Vtip (element 1); mass	8.39 mm/usec ; .069 g
V (element 100); mass	0.19 ; 2.75
Jet mass	66.7 g
Jet energy	.216 megajoules

Jet tip velocity recovers to that of the baseline charge, but the tip mass is about 60% of the point initiated liquid charge. Jet mass recovers back at element 39, but then begins to drop off by about 10% back to element 73. Total jet energy is still less than half of the baseline charge.

The liquid charge was then subcalibered as shown in Figure 4. The charge diameter is now 140mm rather than 83 as in the baseline charge. Confinement in this charge is 5 mm thick. This charge was ring initiated at a charge height of 57 mm and a radius of 70 mm.

Subcaliber Ring Initiated Liquid Charge (SRILC)

Vtip (element 1); mass	8.34 mm/usec ; .070 g
V (element 100); mass	4.66 ; .653
Jet mass	32.1 g
Jet energy	.616 megajoules

Jet tip velocity is maintained and jet energy increases. However, jet mass is cut in half and the tail velocity is too high for practical application. This charge was then modified by tapering the confinement down at the base, in hopes of bringing the jet energy and tail velocity down. Figure 5 shows this geometry. The charge diameter at the apex remains 140mm and tapers to 120 mm at the liner base. The same initiation is used as last time.

Subcaliber Ring Initiated Tapered Liquid Charge (SRITLC)

Vtip (element 1); mass	8.45 mm/usec ; .068 g
V (element 100); mass	3.21 ; .911
Jet mass	36.3 g
Jet energy	.542 megajoules

The jet parameters are moving in the right direction, but are clearly not going to match the octol load. It appears that any more tapering will only reduce the jet energy below the baseline charge, despite the still

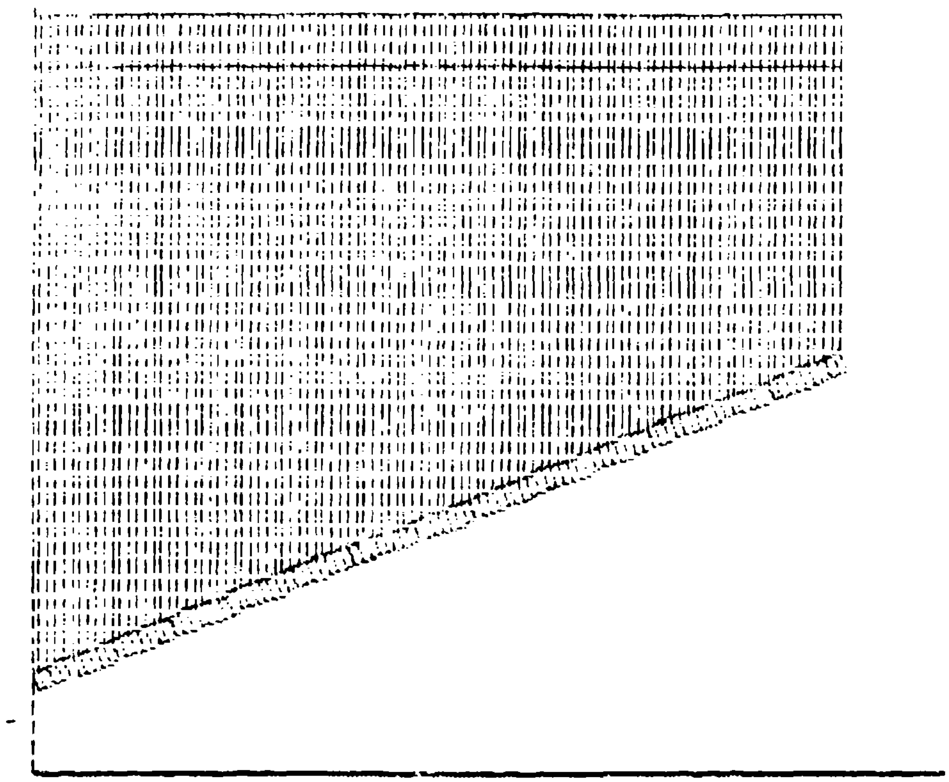


Figure 4. Subcaliber Liquid Charge

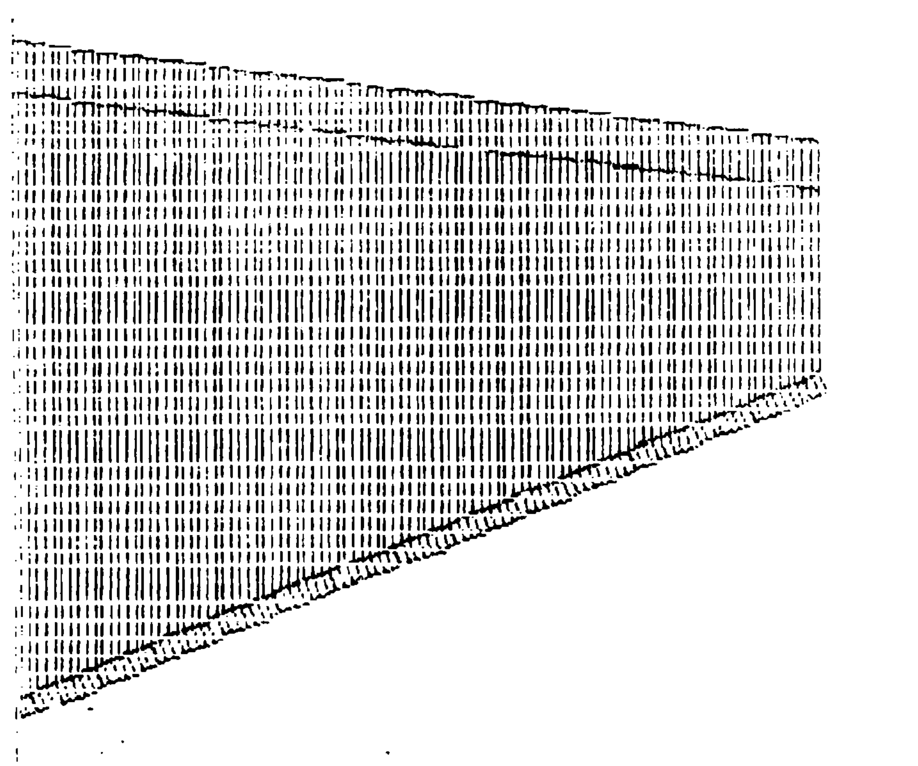


Figure 5. Subcaliber Tapered Liquid Charge

elevated tail velocity. Tip velocity is good, yet total jet mass is still half of the baseline charge.

To see how more tapering affects the jet parameters, the charge was given the most extreme taper possible -- 140 mm at apex and 83 mm at the base, as shown in Figure 6. Initiation is at a radius of 70 mm at a head height of 65 mm. The results are:

Subcaliber Ring Initiated Extremely Tapered Liquid Charge (SRIETLC)

Vtip (element 6); mass	8.32 mm/usec ; .087 g
V (element 100); mass	.28 ; 2.78
Jet mass	66.3 g
Jet energy	.380 megajoules

As expected, the total jet energy is down. The tip and tail velocities are nearly that of the baseline charge, as well as the tail mass. Total jet mass is nearly the same, but tip mass is about 50% of the baseline charge.

Summary

Charge	Vtip mm/usec	Mtip grams	Vtail mm/usec	Mtail grams	Mjet grams	Ejet MJ
BOC	8.31	.177	.33	2.77	71.6	.543
BLC	5.67	.128	.19	2.76	69.3	.206
RILC	8.39	.069	.19	2.75	66.7	.216
SRILC	8.34	.070	4.66	.653	32.1	.616
SRITLC	8.45	.068	3.21	.911	36.3	.542
SRIETLC	8.32	.087	.28	2.78	66.3	.380

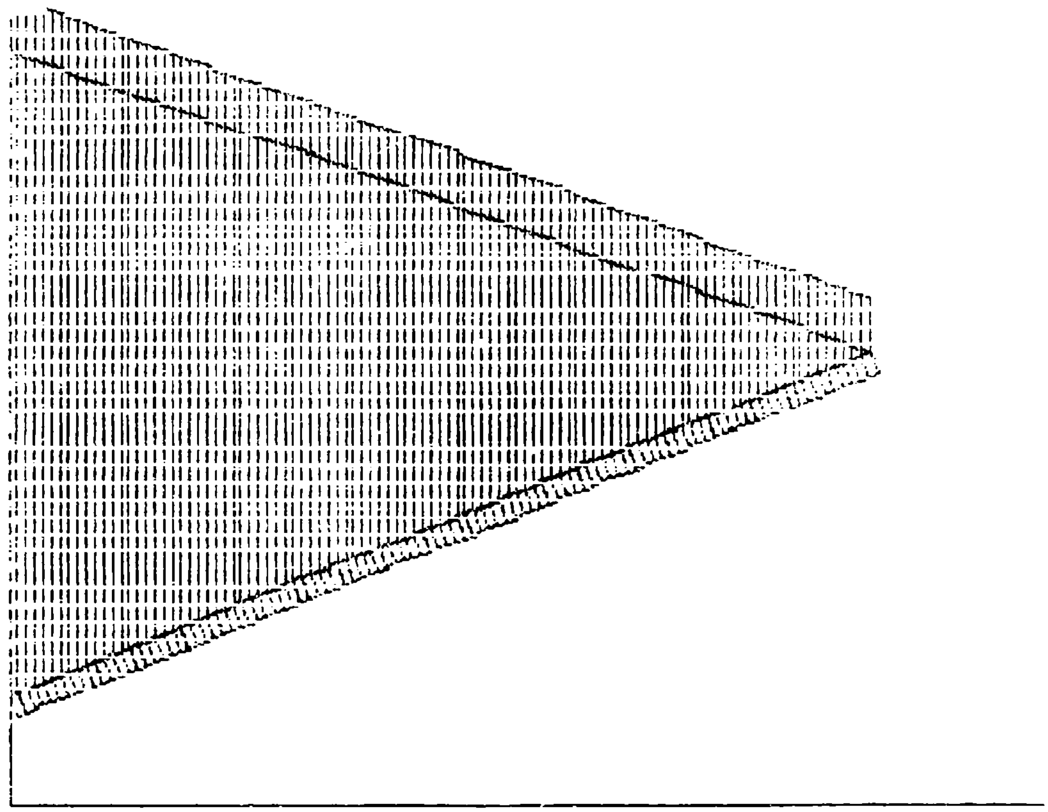


Figure 6. Subcaliber Extremely Tapered Liquid Charge

Conclusions

In spite of the gross assumptions of the model, the results appear to be intuitively correct. The model, perhaps, does not give accurate absolute results, but the relative changes in the jet parameters between charges makes sense. In this limited capacity, the model has some utility in this analysis. It appears from the results that of the six jet parameters evaluated (jet tip velocity and mass, tail velocity and mass, jet mass, and jet energy) at most four parameters can be reasonably maintained at the expense of the other two. However, under no conditions could jet tip mass be maintained closely to that of the baseline charge. It is, of course, up to the investigator to determine which parameters are critical to the experiment.

The best results appear with the use of ring initiation and a tapered charge. This may cause some headache in manufacturing and assembly, but can certainly be done with liquid explosives. One advantage of point initiation, however, is that more head height takes out alignment errors. Obviously, more precision will be needed for ring initiation.

References

1. Kennedy, J.E., "Gurney Energy of Explosives: Estimation of the Velocity and Impulse Imparted to Driven Metal," Sandia Laboratories, Albuquerque, New Mexico. December 1970.

2. DiPersio, Robert; Simon, Julius; Merendino, Alfred B., "Penetration of Shaped-Charge Jets into Metallic Targets," Ballistic Research Laboratories Report No. 1296. September 1965.

Appendix A

Computer Model Output

Legend:

E#	Element number
Z	Element axial position (mm)
TJ	Element time to reach axis (usec after charge initiation)
SM	Element slug mass (grams)
VS	Element slug speed (mm/usec)
JM	Element jet mass (grams)
VJ	Element jet speed (mm/usec)
BETA	Element collapse angle into stagnation point (degrees)
VF	Element flow speed into stagnation point (mm/usec)
FLAG	Integer flag if flow speed exceeds critical velocity

LINER RHO, EXPL RHO, CONFINEMENT RHO 1.77 Octol Basic 33 deg

8.9000000	~~1.7~~000000	2.8000000

V CRITICAL, DET VEL. GURNEY ENERGY BOC

4.8600000	8.5000000	2.8300000

CHARGE HEIGHT BEHIND APEX, DETONATION RADIUS

67.6000000	.0000000

E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
1	6.97	11.38	.8443	.55	.1136	8.23	40.28	3.84	0
2	8.02	11.58	.8712	.56	.1188	8.26	40.54	3.85	0
3	9.08	11.79	.8981	.56	.1242	8.28	40.80	3.86	0
4	10.14	11.99	.9253	.56	.1292	8.31	40.98	3.87	0
5	11.19	12.19	.9522	.57	.1345	8.33	41.20	3.88	0
6	12.24	12.39	.9793	.57	.1397	8.34	41.38	3.89	0
7	13.29	12.59	1.0063	.57	.1449	8.35	41.55	3.89	0
8	14.34	12.80	1.0331	.57	.1504	8.35	41.77	3.89	0
9	15.39	13.00	1.0600	.57	.1556	8.35	41.93	3.89	0
10	16.43	13.20	1.0870	.57	.1609	8.34	42.09	3.89	0
11	17.47	13.40	1.1139	.57	.1662	8.33	42.24	3.88	0
12	18.51	13.61	1.1408	.57	.1715	8.32	42.39	3.88	0
13	19.55	13.81	1.1679	.57	.1767	8.31	42.50	3.87	0
14	20.59	14.01	1.1947	.56	.1820	8.29	42.65	3.86	0
15	21.62	14.22	1.2215	.56	.1875	8.26	42.78	3.85	0
16	22.65	14.42	1.2484	.55	.1928	8.23	42.91	3.84	0
17	23.68	14.63	1.2753	.55	.1982	8.20	43.03	3.83	0
18	24.70	14.83	1.3023	.55	.2034	8.17	43.13	3.81	0
19	25.73	15.04	1.3288	.54	.2090	8.13	43.27	3.80	0
20	26.75	15.25	1.3560	.54	.2142	8.10	43.35	3.78	0
21	27.77	15.46	1.3826	.53	.2198	8.05	43.47	3.76	0
22	28.78	15.67	1.4095	.52	.2252	8.01	43.58	3.74	0
23	29.90	15.89	1.4362	.52	.2305	7.96	43.67	3.72	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
24	30.81	16.09	1.4628	.51	.2364	7.91	43.80	3.70	0
25	31.81	16.30	1.4895	.50	.2418	7.86	43.89	3.68	0
26	32.82	16.52	1.5159	.49	.2476	7.80	44.01	3.65	0
27	33.82	16.73	1.5424	.48	.2533	7.74	44.12	3.63	0
28	34.83	16.95	1.5689	.48	.2590	7.68	44.23	3.60	0
29	35.82	17.17	1.5953	.47	.2649	7.62	44.34	3.58	0
30	36.82	17.39	1.6212	.46	.2712	7.55	44.49	3.55	0
31	37.81	17.62	1.6478	.45	.2769	7.49	44.58	3.52	0
32	38.90	17.84	1.6734	.44	.2834	7.41	44.73	3.49	0
33	39.79	18.07	1.6995	.43	.2897	7.34	44.87	3.46	0
34	40.78	18.30	1.7252	.42	.2960	7.27	45.00	3.42	0
35	41.76	18.53	1.7513	.41	.3024	7.19	45.13	3.39	0
36	42.74	18.76	1.7765	.40	.3092	7.11	45.29	3.36	0
37	43.72	19.00	1.8020	.39	.3160	7.03	45.45	3.32	0
38	44.70	19.24	1.8270	.37	.3233	6.95	45.63	3.29	0
39	45.67	19.48	1.8520	.36	.3304	6.87	45.79	3.25	0
40	46.64	19.72	1.8772	.35	.3376	6.78	45.96	3.22	0
41	47.61	19.97	1.9016	.34	.3453	6.70	46.16	3.18	0
42	48.58	20.22	1.9260	.33	.3533	6.61	46.37	3.14	0
43	49.54	20.48	1.9498	.31	.3614	6.51	46.59	3.10	0
44	50.51	20.74	1.9743	.30	.3694	6.43	46.78	3.06	0
45	51.47	21.00	1.9974	.29	.3784	6.33	47.04	3.02	0
46	52.42	21.26	2.0212	.28	.3871	6.24	47.27	2.98	0
47	53.38	21.53	2.0439	.26	.3962	6.14	47.53	2.94	0
48	54.33	21.81	2.0670	.25	.4057	6.05	47.79	2.90	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
49	55.28	22.09	2.0893	.24	.4159	5.95	48.07	2.86	0
50	56.23	22.37	[illegible]	.22	.4262	5.85	48.40	2.81	0
51	57.17	22.6[illegible]	[illegible]	.21	.436[illegible]	5.75	48.67	2.77	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
56	61.8[illegible]	24.1[illegible]	2.2[illegible]	.14	.4967	5.24	50.50	2.55	0
57	62.80	24.52	2.2519	.13	.5108	5.13	50.93	2.50	0
58	63.73	24.85	2.2699	.11	.5248	5.02	51.36	2.46	0
59	64.66	25.19	2.2872	.10	.5400	4.92	51.83	2.41	0
60	65.58	25.54	2.3037	.08	.5554	4.81	52.30	2.36	0
61	66.50	25.90	2.3196	.07	.5721	4.70	52.82	2.32	0
62	67.42	26.26	2.3341	.05	.5895	4.59	53.36	2.27	0
63	68.34	26.64	2.3485	.03	.6076	4.48	53.92	2.22	0
64	69.25	27.03	2.3615	.02	.6265	4.36	54.51	2.17	0
65	70.16	27.42	2.3737	.00	.6467	4.25	55.13	2.12	0
66	71.07	27.83	2.3843	-.02	.6682	4.14	55.79	2.08	0
67	71.97	28.25	2.3948	-.03	.6903	4.02	56.46	2.03	0
68	72.88	28.69	2.4026	-.05	.7143	3.91	57.20	1.98	0
69	73.77	29.14	2.4101	-.07	.7394	3.79	57.96	1.93	0
70	74.67	29.61	2.4155	-.08	.7658	3.68	58.77	1.88	0
71	75.56	30.10	2.4201	-.10	.7938	3.56	59.60	1.83	0
72	76.45	30.60	2.4223	-.12	.8236	3.45	60.49	1.78	0
73	77.34	31.12	2.4232	-.14	.8551	3.33	61.42	1.73	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
74	78.22	31.67	2.4219	-.16	.8896	3.21	62.41	1.68	0
75	79.10	32.24	2.4189	-.18	.9239	3.09	63.43	1.64	0
76	79.97	32.83	2.4133	-.19	.9616	2.98	64.52	1.59	0
77	80.84	33.46	2.4054	-.21	1.0017	2.86	65.67	1.54	0
78	81.71	34.11	2.3951	-.23	1.0443	2.74	66.88	1.49	0
79	82.57	34.81	2.3824	-.25	1.0894	2.63	68.13	1.44	0
80	83.43	35.54	2.3665	-.27	1.1372	2.51	69.46	1.39	0
81	84.29	36.32	2.3484	-.29	1.1879	2.40	70.84	1.34	0
82	85.14	37.15	2.3264	-.31	1.2417	2.28	72.30	1.30	0
83	85.98	38.03	2.3017	-.33	1.2991	2.17	73.83	1.25	0
84	86.82	38.98	2.2731	-.35	1.3595	2.05	75.43	1.20	0
85	87.65	40.00	2.2417	-.37	1.4235	1.94	77.10	1.15	0
86	88.48	41.11	2.2060	-.39	1.4910	1.83	78.85	1.11	0
87	89.31	42.32	2.1674	-.40	1.5623	1.72	80.66	1.06	0
88	90.12	43.65	2.1243	-.42	1.6371	1.61	82.56	1.02	0
89	90.93	45.12	2.0784	-.44	1.7157	1.50	84.52	.97	0
90	91.73	46.76	2.0279	-.45	1.7980	1.40	86.56	.92	0
91	92.52	48.62	1.9746	-.46	1.8839	1.29	88.65	.88	0
92	93.31	50.74	1.9172	-.47	1.9732	1.19	90.82	.83	0
93	94.08	53.20	1.8571	-.48	2.0659	1.09	93.05	.78	0
94	94.84	56.12	1.7935	-.48	2.1613	.98	95.34	.73	0
95	95.59	59.66	1.7277	-.48	2.2598	.88	97.67	.68	0
96	96.31	64.10	1.6592	-.47	2.3601	.78	100.04	.63	0
97	97.02	69.94	1.5893	-.45	2.4625	.68	102.45	.57	0
98	97.69	78.16	1.5184	-.42	2.5656	.57	104.86	.50	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
99	98.32	91.10	1.4476	-.38	2.6686	.46	107.25	.42	0
100	98.87	116.67	1.3792	-.30	2.7692	.33	109.58	.32	0

SLUG MASS (GMS) 183.7327000
JET MASS (GMS) 71.5785400
JET ENERGY (MJ) 5.434889E-001

Liquid / ballic

"BLC"

LINER RHO, EXPL RHO, CONFINEMENT RHO
8.9600000 1.1000000 2.8000000
V CRITICAL, DET VEL, GURNEY ENERGY
4.8600000 6.3000000 2.0400000
CHARGE HEIGHT BEHIND APEX, DETONATION RADIUS
67.6000000 .0000000

E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
1	6.67	15.62	.8490	.36	.1088	5.66	39.39	2.65	0
2	7.71	15.91	.8764	.36	.1137	5.67	39.61	2.66	0
3	8.75	16.20	.9037	.36	.1185	5.68	39.82	2.66	0
4	9.79	16.49	.9311	.36	.1234	5.68	40.01	2.66	0
5	10.82	16.78	.9585	.36	.1282	5.68	40.13	2.66	0
6	11.85	17.07	.9859	.36	.1331	5.68	40.35	2.66	0
7	12.88	17.36	1.0131	.36	.1381	5.67	40.53	2.66	0
8	13.91	17.65	1.0405	.35	.1429	5.66	40.67	2.65	0
9	14.93	17.95	1.0679	.35	.1478	5.65	40.81	2.65	0
10	15.96	18.24	1.0952	.35	.1527	5.63	40.95	2.64	0
11	16.98	18.53	1.1226	.35	.1575	5.61	41.07	2.63	0
12	18.00	18.83	1.1499	.35	.1625	5.59	41.20	2.62	0
13	19.01	19.13	1.1772	.34	.1674	5.57	41.32	2.61	0
14	20.03	19.43	1.2045	.34	.1723	5.54	41.43	2.60	0
15	21.04	19.72	1.2317	.34	.1773	5.51	41.55	2.59	0
16	22.05	20.03	1.2590	.33	.1823	5.48	41.66	2.58	0
17	23.05	20.33	1.2863	.33	.1872	5.45	41.76	2.56	0
18	24.06	20.63	1.3137	.32	.1920	5.42	41.85	2.55	0
19	25.06	20.94	1.3408	.32	.1970	5.38	41.95	2.53	0
20	26.06	21.25	1.3681	.31	.2022	5.34	42.06	2.51	0
21	27.06	21.56	1.3950	.31	.2073	5.30	42.16	2.50	0
22	28.05	21.87	1.4223	.30	.2124	5.26	42.26	2.48	0
23	29.05	22.19	1.4493	.30	.2175	5.22	42.35	2.46	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
24	30.04	22.51	1.4762	.29	.2229	5.17	42.47	2.44	0
25	31.03	22.83	1.5033	.29	.2280	5.12	42.56	2.42	0
26	32.01	23.15	1.5300	.28	.2335	5.07	42.68	2.40	0
27	33.00	23.48	1.5569	.27	.2389	5.02	42.78	2.37	0
28	33.98	23.81	1.5834	.27	.2445	4.97	42.91	2.35	0
29	34.96	24.15	1.6102	.26	.2500	4.92	43.02	2.33	0
30	35.93	24.49	1.6367	.25	.2558	4.86	43.14	2.30	0
31	36.91	24.83	1.6631	.25	.2617	4.81	43.27	2.28	0
32	37.88	25.17	1.6891	.24	.2677	4.75	43.41	2.25	0
33	38.85	25.52	1.7156	.23	.2736	4.69	43.54	2.23	0
34	39.82	25.88	1.7414	.23	.2798	4.63	43.69	2.20	0
35	40.79	26.24	1.7674	.22	.2863	4.57	43.85	2.18	0
36	41.76	26.60	1.7929	.21	.2928	4.51	44.01	2.15	0
37	42.72	26.97	1.8187	.21	.2994	4.45	44.17	2.12	0
38	43.68	27.35	1.8441	.20	.3062	4.39	44.34	2.09	0
39	44.64	27.73	1.8691	.19	.3133	4.33	44.53	2.07	0
40	45.60	28.11	1.8743	.18	.3205	4.26	44.72	2.04	0
41	46.55	28.51	1.9189	.18	.3279	4.20	44.92	2.01	0
42	47.51	28.90	1.9436	.17	.3357	4.13	45.14	1.98	0
43	48.46	29.31	1.9677	.16	.3436	4.07	45.36	1.95	0
44	49.41	29.72	1.9720	.15	.3517	4.00	45.59	1.92	0
45	50.36	30.14	2.0156	.15	.3602	3.94	45.83	1.90	0
46	51.31	30.57	2.0392	.14	.3690	3.87	46.09	1.87	0
47	52.25	31.00	2.0624	.13	.3778	3.80	46.34	1.84	0
48	53.20	31.45	2.0853	.12	.3874	3.74	46.63	1.81	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
49	54.14	31.90	2.1078	.12	.3969	3.67	46.92	1.78	0
50	55.09	32.36	2.1299	.11	.4[illegible]71	3.60	47.23	1.75	[illegible]
51	56.02	32.83	2.1517	.10	.4176	3.53	47.55	1.72	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

17

56	60.68	35.34	2.2567	.06	.4765	3.19	49.39	1.56	0
57	61.61	35.87	2.2730	.05	.4898	3.12	49.80	1.53	0
58	62.54	36.42	2.2909	.04	.5038	3.05	50.25	1.50	0
59	63.46	36.99	2.3087	.03	.5185	2.98	50.71	1.47	0
60	64.38	37.57	2.3253	.03	.5338	2.90	51.20	1.44	0
61	65.30	38.16	2.3419	.02	.5498	2.83	51.70	1.41	0
62	66.22	38.78	2.3567	.01	.5667	2.76	52.24	1.38	0
63	67.14	39.41	2.3717	.00	.5845	2.69	52.80	1.35	0
64	68.05	40.05	2.3851	-.01	.6029	2.62	53.38	1.31	0
65	68.96	40.72	2.3980	-.02	.6225	2.55	54.00	1.28	0
66	69.87	41.41	2.4093	-.03	.6432	2.48	54.65	1.25	0
67	70.78	42.13	2.4202	-.04	.6649	2.40	55.32	1.22	0
68	71.67	42.87	2.4292	-.04	.6878	2.33	56.03	1.19	0
69	72.57	43.63	2.4375	-.05	.7120	2.26	56.78	1.16	0
70	73.48	44.42	2.4436	-.06	.7378	2.19	57.58	1.13	0
71	74.39	45.25	2.4494	-.07	.7646	2.12	58.39	1.09	0
72	75.29	46.11	2.4525	-.08	.7934	2.04	59.26	1.06	0
73	76.18	47.00	2.4545	-.09	.8238	1.97	60.17	1.03	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
74	77.08	47.93	2.4546	-.10	.8559	1.90	61.12	1.00	0
75	77.97	48.91	2.4526	-.11	.8901	1.83	62.13	.97	0
76	78.85	49.93	2.4487	-.12	.9263	1.76	63.19	.94	0
77	79.74	51.01	2.4471	-.13	.9651	1.69	64.31	.91	0
78	80.62	52.14	2.4336	-.14	1.0058	1.62	65.47	.88	0
79	81.50	53.33	2.4225	-.15	1.0493	1.55	66.70	.85	0
80	82.37	54.59	2.4081	-.16	1.0955	1.48	68.00	.82	0
81	83.25	55.94	2.3915	-.17	1.1448	1.41	69.36	.79	0
82	84.12	57.37	2.3713	-.18	1.1968	1.34	70.78	.76	0
83	84.98	58.90	2.3403	-.19	1.2524	1.27	72.28	.73	0
84	85.84	60.54	2.3213	-.20	1.3113	1.20	73.86	.70	0
85	86.70	62.31	2.2913	-.21	1.3738	1.14	75.50	.67	0
86	87.56	64.23	2.2571	-.22	1.4399	1.07	77.23	.65	0
87	88.41	66.33	2.2194	-.23	1.5102	1.01	79.04	.62	0
88	89.25	68.63	2.1771	-.24	1.5844	.94	80.93	.59	0
89	90.09	71.18	2.1315	-.25	1.6626	.88	82.90	.56	0
90	90.92	74.03	2.0809	-.25	1.7450	.81	84.96	.53	0
91	91.75	77.24	2.0269	-.26	1.8316	.75	87.10	.51	0
92	92.57	80.93	1.9682	-.27	1.9222	.69	89.32	.48	0
93	93.39	85.19	1.9061	-.27	2.0169	.63	91.62	.45	0
94	94.19	90.24	1.8397	-.27	2.1151	.57	93.99	.42	0
95	94.98	96.37	1.7704	-.27	2.2171	.51	96.43	.39	0
96	95.76	104.07	1.6976	-.27	2.3217	.45	98.93	.36	0
97	96.52	114.18	1.6227	-.26	2.4291	.39	101.48	.32	0
98	97.26	128.39	1.5460	-.24	2.5380	.33	104.06	.29	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
99	97.97	150.79	1.4686	-.22	2.6476	.26	106.64	.24	0
100	98.61	175.06	1.3917	-.17	2.7567	.19	109.21	.18	0

SLUG MASS (GMS) 186.0553000
JET MASS (GMS) 69.2560000
JET ENERGY (MJ) 2.055235E-001

[illegible]

LINER RHO, EXPL RHO, CONFINEMENT RHO
8.9000000 1.1000000 2.8000000

[illegible]

V CRITICAL, DET VEL, GURNEY ENERGY
4.8600000 6.3000000 2.0400000

CHARGE HEIGHT BEHIND APEX, DETONATION RADIUS
20.0000000 40.0000000

E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
1	4.64	8.71	.8894	.32	.0685	8.39	31.02	4.04	0
2	5.68	8.90	.9171	.32	.0729	8.24	31.50	3.96	0
3	6.72	9.10	.9449	.32	.0774	8.09	31.94	3.89	0
4	7.76	9.30	.9726	.32	.0819	7.95	32.37	3.82	0
5	8.81	9.51	1.0001	.31	.0867	7.81	32.81	3.75	0
6	9.85	9.72	1.0276	.31	.0914	7.67	33.21	3.68	0
7	10.90	9.93	1.0549	.31	.0963	7.54	33.62	3.62	0
8	11.94	10.15	1.0824	.31	.1010	7.42	33.98	3.56	0
9	12.99	10.38	1.1096	.31	.1060	7.30	34.35	3.50	0
10	14.03	10.61	1.1369	.30	.1110	7.18	34.71	3.44	0
11	15.08	10.84	1.1639	.30	.1162	7.06	35.07	3.38	0
12	16.12	11.08	1.1910	.30	.1213	6.95	35.40	3.32	0
13	17.16	11.33	1.2182	.30	.1264	6.84	35.71	3.27	0
14	18.20	11.58	1.2452	.29	.1316	6.73	36.02	3.22	0
15	19.24	11.83	1.2721	.29	.1369	6.63	36.33	3.17	0
16	20.28	12.09	1.2989	.29	.1423	6.52	36.63	3.12	0
17	21.32	12.35	1.3259	.28	.1476	6.42	36.90	3.07	0
18	22.35	12.61	1.3525	.28	.1532	6.32	37.20	3.02	0
19	23.39	12.89	1.3793	.28	.1586	6.23	37.46	2.98	0
20	24.42	13.16	1.4060	.27	.1642	6.13	37.73	2.93	0
21	25.44	13.44	1.4326	.27	.1697	6.04	37.98	2.89	0
22	26.47	13.72	1.4594	.26	.1753	5.95	38.23	2.84	0
23	27.50	14.01	1.4857	.26	.1811	5.86	38.49	2.80	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
24	28.52	14.31	1.5124	.25	.1868	5.77	38.73	2.76	0
25	29.54	14.60	1.5385	.25	.1928	5.68	38.98	2.71	0
26	30.56	14.91	1.5648	.25	.1987	5.59	39.22	2.67	0
27	31.57	15.21	1.5911	.24	.2047	5.51	39.46	2.63	0
28	32.59	15.53	1.6173	.23	.2107	5.42	39.69	2.59	0
29	33.60	15.84	1.6433	.23	.2169	5.34	39.93	2.56	0
30	34.60	16.16	1.6691	.22	.2233	5.26	40.18	2.52	0
31	35.61	16.49	1.6951	.22	.2296	5.18	40.41	2.48	0
32	36.61	16.82	1.7206	.21	.2361	5.09	40.66	2.44	0
33	37.62	17.16	1.7465	.21	.2427	5.01	40.89	2.40	0
34	38.62	17.50	1.7718	.20	.2494	4.93	41.13	2.37	0
35	39.61	17.85	1.7973	.20	.2564	4.85	41.38	2.33	0
36	40.61	18.21	1.8222	.19	.2635	4.77	41.64	2.29	0
37	41.60	18.57	1.8475	.18	.2705	4.70	41.88	2.26	0
38	42.59	18.93	1.8724	.18	.2779	4.62	42.14	2.22	0
39	43.58	19.30	1.8968	.17	.2855	4.54	42.41	2.19	0
40	44.56	19.68	1.9217	.17	.2931	4.47	42.67	2.15	0
41	45.54	20.07	1.9457	.16	.3011	4.39	42.95	2.12	0
42	46.52	20.46	1.9702	.15	.3091	4.31	43.22	2.08	0
43	47.50	20.86	1.9936	.15	.3177	4.24	43.52	2.05	0
44	48.48	21.26	2.0178	.14	.3260	4.16	43.80	2.01	0
45	49.45	21.68	2.0409	.13	.3349	4.09	44.10	1.98	0
46	50.42	22.10	2.0642	.13	.3440	4.01	44.41	1.94	0
47	51.39	22.53	2.0868	.12	.3534	3.94	44.73	1.91	0
48	52.36	22.96	2.1095	.11	.3631	3.86	45.07	1.87	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
49	53.32	23.41	2.1318	.10	.3730	3.79	45.40	1.84	0
50	54.29	23.87	2.1533	.10	.3836	3.71	45.77	1.81	0
51	55.25	24.33	2.1749	.09	.3943	3.64	46.13	1.77	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	46.51	1.74	[illegible]

56	60.01	26.82	2.2755	.05	.4547	3.26	48.17	1.60	0
57	60.96	27.36	2.2944	.05	.4683	3.19	48.63	1.57	0
58	61.90	27.90	2.3121	.04	.4825	3.11	49.11	1.54	0
59	62.85	28.47	2.3300	.03	.4972	3.04	49.59	1.50	0
60	63.79	29.04	2.3462	.02	.5129	2.96	50.12	1.47	0
61	64.72	29.64	2.3625	.01	.5291	2.89	50.65	1.44	0
62	65.66	30.25	2.3774	.01	.5462	2.81	51.22	1.40	0
63	66.59	30.87	2.3922	.00	.5639	2.74	51.80	1.37	0
64	67.52	31.52	2.4053	-.01	.5828	2.66	52.42	1.34	0
65	68.45	32.19	2.4131	-.02	.6025	2.59	53.05	1.30	0
66	69.38	32.87	2.4293	-.03	.6232	2.52	53.73	1.27	0
67	70.30	33.59	2.4399	-.04	.6452	2.44	54.43	1.24	0
68	71.22	34.32	2.4487	-.05	.6682	2.37	55.16	1.21	0
69	72.14	35.08	2.4569	-.06	.6926	2.29	55.93	1.17	0
70	73.06	35.88	2.4630	-.06	.7184	2.22	56.75	1.14	0
71	73.97	36.70	2.4683	-.07	.7456	2.14	57.59	1.11	0
72	74.88	37.55	2.4714	-.08	.7745	2.07	58.48	1.08	0
73	75.79	38.45	2.4731	-.09	.8051	2.00	59.42	1.04	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
74	76.70	39.38	2.4732	-.10	.8373	1.92	60.38	1.01	0
75	77.60	40.35	2.4712	-.11	.8715	1.85	61.41	.98	0
76	78.50	41.37	2.4668	-.12	.9082	1.78	62.49	.95	0
77	79.40	42.45	2.4604	-.13	.9468	1.70	63.62	.92	0
78	80.29	43.58	2.4516	-.14	.9879	1.63	64.81	.89	0
79	81.18	44.77	2.4403	-.15	1.0315	1.56	66.06	.86	0
80	82.07	46.03	2.4257	-.16	1.0780	1.49	67.38	.82	0
81	82.95	47.37	2.4089	-.17	1.1274	1.42	68.75	.79	0
82	83.84	48.80	2.3884	-.18	1.1797	1.35	70.20	.76	0
83	84.71	50.33	2.3651	-.19	1.2356	1.28	71.72	.74	0
84	85.59	51.97	2.3377	-.20	1.2949	1.21	73.32	.71	0
85	86.46	53.75	2.3074	-.21	1.3578	1.14	74.98	.68	0
86	87.32	55.67	2.2726	-.22	1.4244	1.08	76.74	.65	0
87	88.19	57.76	2.2345	-.23	1.4951	1.01	78.57	.62	0
88	89.04	60.07	2.1917	-.24	1.5698	.95	80.48	.59	0
89	89.89	62.61	2.1454	-.25	1.6487	.88	82.48	.56	0
90	90.74	65.46	2.0942	-.25	1.7317	.82	84.56	.54	0
91	91.58	68.68	2.0395	-.26	1.8191	.76	86.73	.51	0
92	92.41	72.35	1.9799	-.27	1.9105	.69	88.98	.48	0
93	93.24	76.62	1.9170	-.27	2.0060	.63	91.30	.45	0
94	94.05	81.67	1.8496	-.27	2.1052	.57	93.71	.42	0
95	94.86	87.80	1.7793	-.27	2.2081	.51	96.17	.39	0
96	95.65	95.50	1.7055	-.27	2.3138	.45	98.71	.36	0
97	96.42	105.61	1.6294	-.26	2.4224	.39	101.29	.32	0
98	97.18	119.82	1.5515	-.24	2.5325	.33	103.90	.29	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
99	97.90	142.22	1.4727	-.21	2.6435	.26	106.52	.24	0
100	98.56	186.51	1.3941	-.17	2.7543	.19	109.14	.18	0

SLUG MASS (GMS) 188.6072000
JET MASS (GMS) 66.7041000
JET ENERGY (MJ) 2.155971E-001

Subcaliber

LINER RHO, EXPL RHO, CONFINEMENT RHO

8.9000000 1.1000000 2.8000000 "SRI-C"

V CRITICAL, DET VEL, GURNEY ENERGY

4.8600000 6.3000000 2.0400000

CHARGE HEIGHT BEHIND APEX, DETONATION RADIUS

57.0000000 70.0000000

E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
1	5.16	16.65	.8882	.38	.0696	8.34	31.28	3.98	0
2	6.18	16.84	.9167	.39	.0734	8.33	31.60	3.97	0
3	7.20	17.03	.9451	.39	.0772	8.33	31.90	3.97	0
4	8.22	17.21	.9734	.39	.0811	8.32	32.20	3.96	0
5	9.25	17.40	1.0019	.40	.0848	8.31	32.45	3.96	0
6	10.27	17.60	1.0299	.40	.0890	8.29	32.77	3.94	0
7	11.30	17.79	1.0581	.40	.0931	8.27	33.05	3.93	0
8	12.33	17.98	1.0863	.40	.0972	8.25	33.30	3.92	0
9	13.35	18.18	1.1143	.40	.1013	8.23	33.56	3.91	0
10	14.38	18.38	1.1423	.40	.1056	8.20	33.82	3.90	0
11	15.41	18.58	1.1702	.40	.1098	8.18	34.07	3.89	0
12	16.44	18.78	1.1982	.41	.1142	8.15	34.31	3.87	0
13	17.47	18.98	1.2261	.41	.1185	8.12	34.54	3.86	0
14	18.51	19.18	1.2539	.41	.1229	8.09	34.77	3.84	0
15	19.54	19.39	1.2817	.41	.1273	8.06	34.99	3.83	0
16	20.57	19.60	1.3094	.41	.1318	8.03	35.21	3.81	0
17	21.60	19.81	1.3371	.41	.1364	8.00	35.43	3.80	0
18	22.64	20.01	1.3647	.41	.1410	7.97	35.64	3.78	0
19	23.67	20.23	1.3922	.41	.1456	7.93	35.84	3.76	0
20	24.71	20.44	1.4201	.41	.1502	7.90	36.03	3.75	0
21	25.74	20.65	1.4474	.41	.1550	7.87	36.24	3.73	0
22	26.77	20.87	1.4752	.41	.1595	7.84	36.40	3.71	0
23	27.81	21.09	1.5024	.41	.1644	7.80	36.60	3.69	0

E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
24	28.84	21.30	1.5300	.41	.1692	7.76	36.78	3.68	0
25	29.88	21.53	1.5573	.41	.1740	7.72	36.96	3.66	0
26	30.91	21.75	1.5848	.41	.1787	7.69	37.12	3.64	0
27	31.95	21.97	1.6123	.41	.1834	7.66	37.28	3.62	0
28	32.98	22.19	1.6395	.41	.1885	7.62	37.46	3.61	0
29	34.01	22.42	1.6668	.40	.1934	7.58	37.62	3.59	0
30	35.05	22.65	1.6943	.40	.1982	7.54	37.76	3.57	0
31	36.08	22.88	1.7214	.40	.2033	7.50	37.93	3.55	0
32	37.11	23.11	1.7485	.40	.2082	7.47	38.08	3.53	0
33	38.15	23.34	1.7759	.40	.2133	7.43	38.23	3.51	0
34	39.18	23.57	1.8031	.40	.2182	7.39	38.36	3.50	0
35	40.21	23.81	1.8307	.40	.2230	7.36	38.48	3.48	0
36	41.24	24.04	1.8573	.40	.2284	7.31	38.65	3.46	0
37	42.28	24.28	1.8849	.39	.2332	7.28	38.76	3.44	0
38	43.31	24.52	1.9120	.39	.2383	7.24	38.89	3.42	0
39	44.34	24.76	1.9388	.39	.2436	7.20	39.03	3.40	0
40	45.37	25.00	1.9662	.39	.2486	7.16	39.15	3.39	0
41	46.40	25.24	1.9931	.39	.2537	7.12	39.27	3.37	0
42	47.43	25.49	2.0204	.39	.2589	7.08	39.39	3.35	0
43	48.45	25.73	2.0473	.38	.2640	7.05	39.51	3.33	0
44	49.48	25.98	2.0743	.38	.2695	7.00	39.64	3.31	0
45	50.51	26.23	2.1013	.38	.2744	6.97	39.74	3.29	0
46	51.54	26.48	2.1296	.38	.2796	6.93	39.85	3.28	0
47	52.56	26.73	2.1551	.37	.2851	6.89	39.97	3.26	0
48	53.59	26.99	2.1821	.37	.2905	6.85	40.09	3.24	0

E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
49	54.61	27.24	2.2091	.37	.2956	6.81	40.19	3.22	0
50	55.63	27.50	2.2358	.37	.3012	6.77	40.31	3.20	0
51	56.66	27.76	2.2626	.36	.3066	6.7[illegible]	40.4[illegible]	3.18	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	40.54	[illegible]	[illegible]

21

56	61.76	29.08	2.3961	.35	.3341	6.53	40.95	3.09	0
57	62.78	29.35	2.4229	.35	.3398	6.49	41.06	3.07	0
58	63.79	29.62	2.4495	.34	.3452	6.45	41.15	3.05	0
59	64.81	29.89	2.4759	.34	.3513	6.41	41.28	3.03	0
60	65.82	30.16	2.5022	.34	.3569	6.37	41.38	3.01	0
61	66.84	30.44	2.5293	.33	.3624	6.33	41.47	3.00	0
62	67.85	30.71	2.5554	.33	.3681	6.29	41.57	2.98	0
63	68.86	30.99	2.5818	.33	.3743	6.24	41.69	2.96	0
64	69.88	31.29	2.6080	.32	.3800	6.21	41.78	2.94	0
65	70.89	31.56	2.6342	.32	.3864	6.16	41.91	2.92	0
66	71.90	31.84	2.6600	.32	.3924	6.12	42.02	2.90	0
67	72.91	32.13	2.6865	.31	.3985	6.08	42.13	2.88	0
68	73.91	32.42	2.7123	.31	.4046	6.04	42.24	2.86	0
69	74.92	32.71	2.7390	.31	.4105	6.00	42.33	2.85	0
70	75.93	33.00	2.7645	.30	.4168	5.96	42.44	2.83	0
71	76.93	33.30	2.7906	.30	.4234	5.91	42.56	2.81	0
72	77.93	33.59	2.8161	.29	.4297	5.87	42.68	2.79	0
73	78.94	33.89	2.8419	.29	.4363	5.83	42.79	2.77	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
74	79.94	34.19	2.8675	.29	.4430	5.79	42.91	2.75	0
75	80.94	34.50	2.8930	.28	.4498	5.75	43.04	2.73	0
76	81.94	34.80	2.9188	.28	.4561	5.71	43.14	2.71	0
77	82.94	35.11	2.9440	.27	.4632	5.66	43.27	2.69	0
78	83.94	35.42	2.9694	.27	.4700	5.62	43.39	2.67	0
79	84.93	35.73	2.9946	.27	.4772	5.58	43.52	2.66	0
80	85.93	36.05	3.0200	.26	.4836	5.54	43.62	2.64	0
81	86.92	36.36	3.0448	.26	.4915	5.49	43.78	2.62	0
82	87.92	36.68	3.0691	.25	.4990	5.45	43.92	2.60	0
83	88.91	37.00	3.0948	.25	.5059	5.41	44.03	2.58	0
84	89.90	37.33	3.1195	.24	.5131	5.37	44.15	2.56	0
85	90.89	37.66	3.1440	.24	.5211	5.32	44.31	2.54	0
86	91.88	37.99	3.1680	.24	.5290	5.28	44.45	2.52	0
87	92.87	38.32	3.1926	.23	.5371	5.23	44.60	2.50	0
88	93.85	38.65	3.2162	.23	.5453	5.19	44.76	2.48	0
89	94.84	38.99	3.2412	.22	.5529	5.15	44.88	2.46	0
90	95.83	39.33	3.2647	.22	.5612	5.10	45.04	2.44	0
91	96.81	39.68	3.2892	.21	.5694	5.06	45.18	2.42	0
92	97.79	40.03	3.3120	.21	.5784	5.01	45.36	2.40	0
93	98.77	40.38	3.3366	.20	.5864	4.97	45.49	2.39	0
94	99.75	40.73	3.3592	.20	.5956	4.93	45.67	2.36	0
95	100.73	41.09	3.3826	.19	.6049	4.88	45.84	2.34	0
96	101.71	41.45	3.4055	.19	.6138	4.84	46.01	2.33	0
97	102.69	41.81	3.4284	.18	.6234	4.79	46.19	2.30	0
98	103.66	42.18	3.4514	.18	.6325	4.75	46.35	2.29	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
99	104.64	42.55	3.4735	.17	.6427	4.70	46.55	2.26	0
100	105.61	42.92	3.4959	.17	.6526	4.66	46.73	2.24	0

SLUG MASS (GMS) 223.2490000
JET MASS (GMS) 32.0623100
JET ENERGY (MJ) 6.156031E-001

"CRITIC"

tapered confinement

LINER RHO, EXPL RHO, CONFINEMENT RHO
8.9000000 1.1000000 2.8000000

V CRITICAL, DET VEL, GURNEY ENERGY
4.8600000 6.3000000 2.0400000

CHARGE HEIGHT BEHIND APEX, DETONATION RADIUS
57.0000000 70.0000000

E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
1	5.15	16.65	.8901	.39	.0677	8.45	30.84	4.03	0
2	6.18	16.84	.9188	.40	.0713	8.45	31.14	4.03	0
3	7.20	17.02	.9472	.40	.0751	8.45	31.45	4.02	0
4	8.23	17.21	.9756	.40	.0789	8.43	31.76	4.02	0
5	9.25	17.39	1.0040	.40	.0828	8.42	32.04	4.01	0
6	10.28	17.58	1.0323	.41	.0867	8.41	32.32	4.00	0
7	11.30	17.77	1.0604	.41	.0908	8.39	32.61	3.99	0
8	12.33	17.96	1.0886	.41	.0948	8.37	32.88	3.98	0
9	13.36	18.16	1.1168	.41	.0988	8.35	33.13	3.97	0
10	14.39	18.35	1.1447	.41	.1032	8.31	33.42	3.95	0
11	15.42	18.55	1.1727	.41	.1074	8.28	33.67	3.94	0
12	16.45	18.74	1.2007	.41	.1116	8.26	33.91	3.92	0
13	17.48	18.94	1.2285	.42	.1160	8.22	34.17	3.90	0
14	18.51	19.14	1.2565	.42	.1203	8.19	34.38	3.89	0
15	19.55	19.35	1.2842	.42	.1248	8.15	34.63	3.87	0
16	20.58	19.55	1.3120	.42	.1292	8.12	34.85	3.85	0
17	21.61	19.76	1.3396	.42	.1339	8.08	35.08	3.83	0
18	22.64	19.96	1.3673	.42	.1384	8.04	35.29	3.81	0
19	23.68	20.17	1.3948	.42	.1431	8.00	35.52	3.79	0
20	24.71	20.38	1.4225	.42	.1477	7.96	35.72	3.77	0
21	25.74	20.60	1.4498	.41	.1525	7.92	35.93	3.75	0
22	26.78	20.81	1.4776	.41	.1571	7.88	36.11	3.73	0
23	27.81	21.03	1.5047	.41	.1620	7.83	36.33	3.71	0

24	28.84	21.24	1.5323	.41	.1669	7.79	36.53	3.69	0
25	29.87	21.46	1.5595	.41	.1719	7.74	36.72	3.67	0
26	30.91	21.68	1.5869	.41	.1766	7.70	36.90	3.64	0
27	31.94	21.90	1.6143	.41	.1815	7.65	37.07	3.62	0
28	32.97	22.13	1.6413	.40	.1867	7.60	37.27	3.60	0
29	34.00	22.35	1.6686	.40	.1715	7.56	37.43	3.58	0
30	35.03	22.58	1.6959	.40	.1966	7.51	37.60	3.55	0
31	36.06	22.81	1.7231	.40	.2017	7.46	37.77	3.53	0
32	37.07	23.04	1.7499	.40	.2069	7.41	37.95	3.51	0
33	38.12	23.27	1.7771	.39	.2121	7.36	38.12	3.48	0
34	39.15	23.51	1.8039	.39	.2173	7.31	38.28	3.46	0
35	40.17	23.74	1.8311	.39	.2226	7.26	38.44	3.44	0
36	41.20	23.98	1.8578	.39	.2279	7.21	38.61	3.41	0
37	42.23	24.22	1.8848	.38	.2333	7.16	38.76	3.39	0
38	43.25	24.46	1.9115	.38	.2388	7.10	38.93	3.36	0
39	44.28	24.71	1.9381	.38	.2443	7.05	39.10	3.34	0
40	45.30	24.95	1.9649	.37	.2500	7.00	39.26	3.31	0
41	46.32	25.20	1.9913	.37	.2555	6.94	39.42	3.29	0
42	47.34	25.45	2.0181	.36	.2612	6.89	39.57	3.26	0
43	48.36	25.70	2.0446	.36	.2667	6.84	39.71	3.24	0
44	49.38	25.96	2.0711	.36	.2727	6.78	39.89	3.21	0
45	50.40	26.21	2.0975	.35	.2782	6.73	40.02	3.19	0
46	51.42	26.47	2.1238	.35	.2844	6.67	40.20	3.16	0
47	52.43	26.73	2.1499	.34	.2903	6.61	40.35	3.13	0
48	53.45	26.99	2.1764	.34	.2963	6.56	40.50	3.11	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
49	54.46	27.26	2.2023	.34	.3025	6.50	40.67	3.08	0
50	55.47	27.53	2.2281	.33	.3088	6.44	40.84	3.06	0
51	56.48	27.80	2.2541	.33	.3151	6.38	41.00	3.03	0
52	57.49	28.07	2.2801	.32	.3213	6.33	41.15	3.00	0
53	58.50	28.35	2.3055	.32	.3282	6.27	41.34	2.98	0
54	59.51	28.62	2.3311	.31	.3347	6.21	41.51	2.95	0
55	60.51	28.90	2.3572	.31	.3411	6.15	41.65	2.92	0
56	61.52	29.19	2.3819	.30	.3483	6.09	41.85	2.90	0
57	62.52	29.47	2.4077	.29	.3550	6.03	42.01	2.87	0
58	63.52	29.76	2.4328	.29	.3619	5.97	42.18	2.84	0
59	64.52	30.05	2.4578	.28	.3694	5.91	42.38	2.81	0
60	65.52	30.35	2.4823	.28	.3769	5.85	42.58	2.79	0
61	66.52	30.65	2.5075	.27	.3842	5.79	42.75	2.76	0
62	67.52	30.95	2.5319	.27	.3917	5.73	42.94	2.73	0
63	68.51	31.25	2.5566	.26	.3996	5.67	43.14	2.70	0
64	69.51	31 56	2.5806	.25	.4075	5.61	43.34	2.68	0
65	70.50	31.87	2.6049	.25	.4157	5.55	43.55	2.65	0
66	71.49	32.18	2.6285	.24	.4240	5.48	43.76	2.62	0
67	72.48	32.50	2.6527	.23	.4323	5.42	43.97	2.59	0
68	73.46	32.82	2.6761	.23	.4409	5.36	44.18	2.57	0
69	74.45	33.15	2.6995	.22	.4500	5.30	44.42	2.54	0
70	75.43	33.48	2.7223	.21	.4591	5.23	44.65	2.51	0
71	76.42	33.81	2.7455	.21	.4685	5.17	44.89	2.48	0
72	77.40	34.15	2.7679	.20	.4779	5.11	45.13	2.45	0
73	78.38	34.49	2.7908	.19	.4875	5.04	45.36	2.42	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
74	79.36	34.84	2.8128	.19	.4977	4.98	45.63	2.40	0
75	80.33	35.19	2.8343	.18	.5084	4.91	45.91	2.37	0
76	81.31	35.55	2.8563	.17	.5187	4.85	46.16	2.34	0
77	82.28	35.91	2.8774	.17	.5298	4.78	46.45	2.31	0
78	83.25	36.27	2.8985	.16	.5409	4.72	46.73	2.28	0
79	84.22	36.64	2.9194	.15	.5523	4.65	47.01	2.25	0
80	85.19	37.02	2.9390	.14	.564[illegible]	4.58	47.34	2.22	0
81	86.15	37.40	2.9597	.14	.5765	4.52	47.63	2.19	0
82	87.12	37.79	2.9790	.13	.5891	4.45	47.95	2.16	0
83	[illegible]	[illegible]	[illegible]	.12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

87	91.91	39.83	3.0709	.09	.6588	4.12	49.70	2.02	0
88	92.86	40.25	3.0871	.08	.6744	4.05	50.10	1.99	0
89	93.81	40.69	3.1037	.07	.6904	3.98	50.50	1.96	0
90	94.76	41.13	3.1187	.06	.7072	3.91	50.93	1.92	0
91	95.71	41.59	3.1349	.05	.7236	3.84	51.32	1.90	0
92	96.65	42.05	3.1485	.04	.7419	3.77	51.78	1.87	0
93	97.60	42.52	3.1631	.03	.7599	3.70	52.22	1.84	0
94	98.54	43.00	3.1753	.02	.7795	3.63	52.71	1.80	0
95	99.48	43.49	3.1881	.01	.7993	3.56	53.20	1.77	0
96	100.41	43.99	3.1995	.00	.8198	3.49	53.70	1.74	0
97	101.35	44.50	3.2104	.00	.8413	3.42	54.22	1.71	0
98	102.28	45.02	3.2200	-.01	.8639	3.35	54.77	1.68	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
99	103.21	45.56	3.2287	-.03	.8875	3.28	55.34	1.65	0
100	104.13	46.10	3.2372	-.03	.9112	3.21	55.90	1.62	0

SLUG MASS (GMS) 219.0552000
JET MASS (GMS) 36.2561600
JET ENERGY (MJ) 5.417134E-001

extreme taper

LINER RHO, EXPL RHO, CONFINEMENT RHO

8.9000000 1.1000000 2.8000000 ``SAFETIC

V CRITICAL, DET VEL, GURNEY ENERGY

4.8600000 6.3000000 2.0400000

CHARGE HEIGHT BEHIND APEX, DETONATION RADIUS

65.0000000 70.0000000

E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
1	5.33	17.68	.8898	.41	.0680	8.31	30.91	3.95	0
2	6.36	17.87	.9184	.41	.0717	8.32	31.22	3.95	0
3	7.39	18.06	.9470	.42	.0753	8.34	31.49	3.96	0
4	8.42	18.25	.9753	.42	.0792	8.33	31.81	3.96	0
5	9.45	18.44	1.0038	.42	.0829	8.34	32.07	3.96	0
6	10.47	18.63	1.0320	.43	.0870	8.32	32.38	3.95	0
7	11.51	18.82	1.0603	.43	.0909	8.31	32.64	3.94	0
8	12.54	19.01	1.0884	.43	.0950	8.30	32.92	3.93	0
9	13.57	19.21	1.1164	.43	.0992	8.28	33.20	3.92	0
10	14.60	19.40	1.1444	.43	.1034	8.25	33.47	3.91	0
11	15.63	19.60	1.1724	.43	.1077	8.22	33.73	3.90	0
12	16.66	19.80	1.2003	.43	.1120	8.20	33.97	3.88	0
13	17.70	20.00	1.2281	.43	.1165	8.16	34.23	3.86	0
14	18.73	20.20	1.2558	.43	.1210	8.12	34.49	3.84	0
15	19.76	20.41	1.2835	.43	.1255	8.08	34.73	3.82	0
16	20.79	20.61	1.3111	.43	.1302	8.04	34.98	3.80	0
17	21.82	20.82	1.3387	.43	.1348	8.00	35.21	3.78	0
18	22.85	21.03	1.3661	.43	.1396	7.95	35.45	3.76	0
19	23.88	21.24	1.3936	.43	.1443	7.90	35.67	3.74	0
20	24.91	21.45	1.4210	.43	.1493	7.85	35.92	3.71	0
21	25.94	21.67	1.4481	.42	.1542	7.79	36.15	3.69	0
22	26.97	21.88	1.4754	.42	.1593	7.74	36.38	3.66	0
23	28.00	22.10	1.5024	.42	.1643	7.68	36.60	3.63	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
24	29.03	22.32	1.5296	.41	.1695	7.62	36.82	3.60	0
25	30.05	22.55	1.5565	.41	.1748	7.55	37.06	3.57	0
26	31.08	22.77	1.5832	.41	.1803	7.49	37.29	3.54	0
27	32.10	23.00	1.6099	.40	.1857	7.42	37.54	3.51	0
28	33.12	23.23	1.6366	.40	.1914	7.35	37.76	3.48	0
29	34.14	23.46	1.6632	.39	.1970	7.28	37.98	3.44	0
30	35.16	23.69	1.6895	.39	.2029	7.21	38.23	3.41	0
31	36.18	23.93	1.7160	.38	.2088	7.13	38.46	3.38	0
32	37.20	24.17	1.7420	.37	.2148	7.06	38.70	3.34	0
33	38.21	24.41	1.7682	.37	.2211	6.98	38.95	3.30	0
34	39.23	24.65	1.7937	.36	.2276	6.89	39.21	3.27	0
35	40.24	24.90	1.8200	.35	.2337	6.82	39.43	3.23	0
36	41.25	25.15	1.8452	.35	.2405	6.73	39.70	3.19	0
37	42.26	25.41	1.8708	.34	.2472	6.65	39.95	3.15	0
38	43.26	25.67	1.8960	.33	.2542	6.56	40.22	3.11	0
39	44.27	25.93	1.9207	.32	.2616	6.47	40.52	3.07	0
40	45.27	26.19	1.9459	.32	.2689	6.38	40.78	3.03	0
41	46.27	26.46	1.9701	.31	.2768	6.29	41.09	2.99	0
42	47.27	26.73	1.9948	.30	.2845	6.20	41.38	2.95	0
43	48.26	27.01	2.0188	.29	.2925	6.11	41.68	2.91	0
44	49.26	27.29	2.0430	.28	.3007	6.02	41.98	2.87	0
45	50.25	27.58	2.0661	.27	.3096	5.92	42.32	2.82	0
46	51.24	27.87	2.0896	.26	.3187	5.82	42.66	2.78	0
47	52.23	28.16	2.1125	.25	.3277	5.73	42.99	2.74	0
48	53.21	28.46	2.1353	.24	.3374	5.63	43.35	2.69	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
49	54.19	28.77	2.1575	.23	.3473	5.53	43.72	2.65	0
50	55.17	29.08	2.1792	.22	.3578	5.43	44.12	2.61	0
51	56.15	29.40	2.2005	.21	.3687	5.33	44.52	2.56	0

56	61.00	31.08	2.3005	.15	.4298	4.82	46.75	2.33	0
57	61.97	31.44	2.3193	.14	.4434	4.71	47.24	2.29	0
58	62.92	31.81	2.3361	.12	.4586	4.60	47.79	2.24	0
59	63.85	32.19	2.3535	.11	.4737	4.50	48.32	2.19	0
60	64.84	32.58	2.3697	.10	.4894	4.39	48.88	2.15	0
61	65.79	32.97	2.3854	.09	.5063	4.29	49.47	2.10	0
62	66.74	3[illegible].38	2.3995	.07	.5240	4.18	50.10	2.05	0
63	67.68	33.80	2.4133	.06	.5428	4.07	50.75	2.01	0
64	68.62	34.23	2.4256	.04	.5624	3.96	51.42	1.96	0
65	69.56	34.67	2.4375	.03	.5831	3.86	52.13	1.91	0
66	70.50	35.13	2.4476	.01	.6049	3.75	52.87	1.87	0
67	71.43	35.60	2.4572	.00	.6279	3.64	53.63	1.82	0
68	72.36	36.09	2.4646	-.02	.6523	3.53	54.45	1.77	0
69	73.28	36.59	2.4714	-.03	.6781	3.42	55.29	1.73	0
70	74.20	37.12	2.4758	-.05	.7055	3.31	56.19	1.68	0
71	75.12	37.66	2.4795	-.06	.7344	3.20	57.11	1.63	0
72	76.04	38.22	2.4808	-.08	.7650	3.09	58.09	1.59	0
73	76.95	38.81	2.4805	-.10	.7978	2.99	59.12	1.54	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
74	77.85	39.42	2.4785	-.11	.8320	2.88	60.18	1.49	0
75	78.76	40.06	2.4738	-.13	.8689	2.77	61.31	1.45	0
76	79.65	40.73	2.4669	-.15	.9080	2.66	62.49	1.40	0
77	80.55	41.44	2.4575	-.16	.9497	2.55	63.73	1.36	0
78	81.44	42.1[illegible]	2.4459	-.18	.9936	2.44	65.02	1.31	0
79	82.32	42.9[illegible]	2.4314	-.20	1.0404	2.34	66.38	1.27	0
80	83.20	43.78	2.4132	-.22	1.0904	2.23	67.82	1.22	0
81	84.08	44.66	2.3929	-.24	1.1434	2.13	69.31	1.18	0
82	84.94	45.59	2.3685	-.25	1.1996	2.02	70.88	1.14	0
83	85.81	46.59	2.3414	-.27	1.2593	1.92	72.51	1.10	0
84	86.67	47.66	2.3100	-.29	1.3225	1.82	74.23	1.05	0
85	87.52	48.82	2.2757	-.31	1.3895	1.71	76.01	1.01	0
86	88.36	50.07	2.2370	-.33	1.4600	1.61	77.87	.97	0
87	89.20	51.44	2.1949	-.34	1.5347	1.52	79.80	.93	0
88	90.03	52.95	2.1484	-.36	1.6131	1.42	81.82	.89	0
89	90.85	54.67	2.0987	-.37	1.6954	1.32	83.90	.85	0
90	91.67	56.48	2.0445	-.39	1.7815	1.23	86.06	.81	0
91	92.47	58.59	1.9873	-.40	1.8712	1.13	88.28	.77	0
92	93.27	61.01	1.9260	-.41	1.9644	1.04	90.57	.73	0
93	94.05	63.82	1.8621	-.42	2.0609	.95	92.90	.68	0
94	94.82	67.16	1.7947	-.42	2.1601	.86	95.30	.64	0
95	95.57	71.24	1.7255	-.42	2.2620	.77	97.73	.59	0
96	96.30	76.38	1.6538	-.41	2.3654	.68	100.20	.55	0
97	97.01	83.18	1.5813	-.40	2.4705	.59	102.68	.49	0
98	97.68	92.87	1.5083	-.37	2.5756	.49	105.15	.43	0
E#	Z	TJ	SM	VS	JM	VJ	BETA	VF	FLAG
99	98.30	108.47	1.4364	-.33	2.6798	.39	107.58	.36	0
100	98.83	140.89	1.3678	-.26	2.7806	.28	109.91	.27	0

SLUG MASS (GMS) 189.0542000
JET MASS (GMS) 66.2571500
JET ENERGY (MJ) 3.804086E-001